Dynamic Decision Structure and Risk Taking

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Abstract

This paper investigates the behaviour in repeated decision situations. The experimental study shows that subjects show low or no risk-aversion, but put very high value on the opportunity to sell the lottery in every stage of the decision problem. There is evidence that risk attitudes depend on whether they are measured by comparing the certainty equivalent and the expected value of a lottery or by preferences over mean-preserving spreads.

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1. Introduction

In an influential article on dynamic decision-making under uncertainty, MACHINA (1989) distinguishes *static* from *dynamic* choice situations according to whether a decision maker has to determine his course of action irrevocably "before any of the alternative lotteries (or stages of compound lotteries) are resolved" or whether the choice "involves decisions that are made after the resolution of some uncertainty" (p. 1632). From a purely decision-theoretic point of view, it appears unreasonable that a decision maker should be influenced by information, if the action cannot be conditioned on this information. Dynamic choice situations are characterized precisely by the opportunity to act on information which becomes available in the course of the resolution of uncertainty. In this context, Machina suggests a notion of *dynamic consistency* which does take into account non-consequentialist behaviour as is implied by various non-expected utility models. Dynamic consistency requires an agent, after receiving some information, to choose an action which is optimal relative to all acts that have the same history.

Experimental studies of dynamic decision-making have found substantial evidence that the timing of the resolution of uncertainty has an impact on dynamic decision-making even if the agents know that they cannot act on the information revealed over time. In an experimental study designed to test alternative theories of dynamic decision-making, CUBITT, STARMER, AND SUGDEN (1998) find consistent violation of the principle of *timing independence*. The principle of timing independence requires a decision maker's choice of action to be independent of information which does not affect the relative likelihood of the outcomes from their choice. Cubitt, Starmer, and Sugden find that subjects are less risk-averse if they are allowed to condition their actions on the irrelevant event.

GNEEZY AND POTTERS (1997) find that decision makers invest significantly less in situations where they can re-adjust their investment after each random draw. Moreover, the overall performance of investors with flexibility to adjust was substantially worse than the results obtained by the investors without this option. Following THALER, TVERSKI, KAHNEMAN, AND SCHWARTZ (1997), Gneezy and Potters attribute this behaviour to *myopic loss aversion*.

From the theoretical perspective, it is not obvious how a decision maker should invest in the experimental situation of Gneezy and Potters. Even an expected-utility-maximising agent might behave differently when she cannot adjust her investment in the light of upcoming information compared to a situation where this is possible. Two issues are important. If there is no adjustment possible, one is essentially in a situation of static decision-making. In such cases, an expected utility maximiser values a sequence of lotteries as a compound lottery. In contrast, if investment can be adjusted after information becomes available then, depending on risk attitudes and resulting changes in wealth, the decision may be modified.

In this study, we try to gain more insight in the principles guiding agents' behaviour in dynamic choice situations. Repeating an independent random draw has in itself a risk-reducing diversification effect. This may partly explain the observed tendency to invest more in a risky asset if a decision maker has to commit the investment over several consecutive periods (see the early anecdotic evidence of Samuelson, 1963). In contrast, the possibility to make investments in successive periods offers the agent an opportunity to wait for additional information which may help to avoid future losses. Thus, risk-averse subjects may actually prefer this option, even if they do better on average without it. The experiment in this study is designed to shed new light on these issues.

The question of how decision makers view and evaluate successive choices is of particular relevance for the design of experiments itself. When accounting for experimental results (see CAMERER (1995) for a survey), one almost always applies the model of risky decision making to the basic decision task and not to the repeated situation, although repeating the same risky choices may weaken the effects of different risk attitudes. In our study the crucial stochastic event occurs either once or twice and it is explicitly taken into account how optimal behaviour depends on risk attitude. We want to test whether the smaller variance of the final payoff expectations in the once repeated situation influences actual behaviour as predicted by theory.

Our experiment studies decision makers' evaluations for a two–period payoff depending on just one or two chance moves. In a third treatment participants have the option to trade the lottery after the first stage. With this design, we hope to gain in-sights about

- whether subjects understand the diversification effect of a repeated lottery,
- how they react to information revealed depending on whether they are allowed to act on this information, and
- how they value the option to sell the second stage of a lottery in the light of the first-stage results.

In *Treatment A* participants are endowed with a lottery $\mathcal{L}$ which pays with equal probability a high premium $2 \cdot \overline{p}$ and a low premium $2 \cdot \underline{p}$ where $\overline{p} > \underline{p} > 0$. What they actually have to choose is the limit price b_1 above which they are willing to sell the lottery. If the randomly selected price p for $\mathcal{L}$ exceeds b_1, the participant gets the price p in exchange for the lottery $\mathcal{L}$. Otherwise, the lottery is played and the participant receives the prize. Clearly, the only dominant strategy is to bid the price at which one is indifferent between selling and not selling the lottery (see BECKER, DEGROOT, AND MARSHAK (1964)). In essence, we apply the incentive compatible random price mechanism to elicit the willingness to accept for the basic lottery $\mathcal{L}$. The limit price b_1 is the only decision of a participant.

In *Treatment B,* the only decision is again the limit price b_2 for which one is willing to sell the repeated lottery. Here the lottery yields the sum of the returns from two successive and independent draws of the prizes $\overline{p}$ and $\underline{p}$. The return from the repeated lottery is now $2 \cdot \overline{p}$ and $2 \cdot \underline{p}$, each with probability $\frac{1}{4}$, and $\overline{p} + \underline{p}$ with probability $\frac{1}{2}$.

Treatment C has also two chance moves but a participant is free to sell the lottery in the first *and* the second stage. More specifically, participants first choose a limit price b_3 for which they would be willing to sell the repeated lottery. If the random price is such that no sale occurs, then the first lottery drawing is carried out. Knowing the payoff from this first stage, $\overline{p}$ or $\underline{p}$, participants choose a second limit price $b_3(\cdot)$ for which they would be willing to sell the final stage of the lottery.

In summary, the basic decision in Treatment A elicits the certainty equivalent for the basic lottery and hence the risk premium of the risky investment. Treatment B determines the certainty equivalent for the once repeated lottery. Finally, Treatment C elicits the certainty

equivalents of the second-stage lottery and the willingness to accept for the two-stage lottery with this additional sales option.
The experiment used a *between-subject-design* where each group of participants encounters only a single treatment and a *within-subject-design* where participants confront the choice situations of all three treatments.
In the following section, we derive the optimal decisions for all three treatments. Section 3 contains the details of our experimental procedure. The main results are described and discussed in section 4. We conclude by summarising our results and comparing them to some previous experimental studies.

2. Optimal decisions

The experiment elicits the value of the lottery by using the *random price mechanism* (Becker, DeGroot, Marshak, (1964)) for which it is a dominant strategy to reveal the certainty equivalent of a lottery. In each treatment, subjects were endowed with a lottery and asked to name a price above which they would sell the lottery. A randomly selected price then determined whether a subject could sell the lottery.
Three treatments are considered. Treatment A assesses the subject's attitude towards risk. Treatment B is similar to Treatment A but allows us to check whether participants understand the diversification effect of a repeated lottery and whether they are influenced by decision-irrelevant information. Treatment C studies the value of the additional option to sell the lottery after partial resolution of uncertainty.
The basic payoff of a lottery is

$$\begin{array}{lll} \overline{p} = 5 & \text{with probability} & \frac{1}{2} \\ \underline{p} = 1 & \text{with probability} & \frac{1}{2} \end{array} .$$

This lottery is repeated once in Treatments B and C. Outcomes are doubled in Treatment A where the basic lottery is played only once. Treatment C allows players to trade the second-stage lottery after the outcome of stage 1 has been observed. The following table summarises the structure of the three treatments.

chance moves take place

decisions take place	*once*	*twice*
once	Treatment A	Treatment B
twice	-	Treatment C

In order to contrast the experimental results with theoretical predictions, we determine the optimal behaviour of an expected utility maximiser in the three treatments.

2.1 Treatment A

In Treatment A, subjects are endowed with the following lottery:

$$\mathcal{L}1 = \begin{cases} 2 \cdot \overline{p} = 10 & \text{with probability} \quad \frac{1}{2} \\ 2 \cdot \underline{p} = 2 & \text{with probability} \quad \frac{1}{2} \end{cases} .$$

Mean and standard deviation of lottery $\mathcal{L}1$ are

$$\mu_1 = 6 \quad \text{and} \quad \sigma_1 = 4.$$

Subjects are asked to quote a price $b_1 \in [1, 10]$ for which they are willing to sell lottery $\mathcal{L}1$. A price $p \in [1, 10]$ is then randomly drawn from a *uniform distribution*. For $p > b_1$, the lottery $\mathcal{L}1$ is sold and the payoff of the subject is p. For $p \leq b_1$, the lottery $\mathcal{L}1$ is played and the subject receives the lottery payout. The following diagram illustrates the sequence of moves.

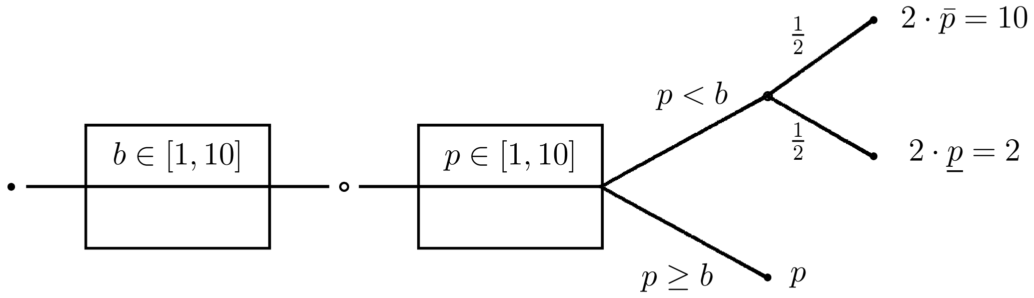

Figure 1: Treatment A

The expected utility from quoting a sales price b is easily computed as

$$V_1(b) := [\frac{u(2 \cdot \underline{p}) + u(2 \cdot \overline{p})}{2}] \cdot \frac{b-1}{9} + \frac{1}{9} \cdot \int_b^{10} u(p)\, dp.$$

Straightforward calculation shows that $V_1(b)$ is a concave function if the von Neumann–Morgenstern utility index u is a strictly increasing function.

In this treatment, subjects face the decision problem:

$$\text{Choose} \quad b \in [1, 10] \quad \text{such that} \quad V_1(b) \quad \text{is maximised.}$$

Differentiating $V_1(b)$ yields the following first order condition which is also sufficient because $V_1(b)$ is concave:

$$\frac{u(2 \cdot \underline{p}) + u(2 \cdot \overline{p})}{2} - u(b_1^*) = 0.$$

It is optimal for the decision maker to offer the certainty equivalent of the lottery as limit price for which the lottery will be sold. Solving for b_1^* yields the optimal quote for the sales price:

$$b_1^* = u^{-1}(\frac{u(2 \cdot \underline{p}) + u(2 \cdot \overline{p})}{2}) = u^{-1}(\frac{u(2) + u(10)}{2}).$$

It is worth noting that the expected utility of the lottery plus sales option exceeds the expected value of the basic lottery. In case of $u(x) = x$ (risk neutrality) one obtains $b_1^* = 6$ and $V_1(b_1^*) = 6\frac{8}{9}$ which is higher than the lottery's expected value of 6 due to the additional expected gains from random prices larger than 6.

2.2 Treatment B

In Treatment B, lottery $\mathcal{L}1$ is once repeated:

$$\mathcal{L}2 = \begin{cases} 2\cdot\overline{p} = 10 & \text{with probability} \quad \frac{1}{4} \\ \overline{p}+\underline{p} = 6 & \text{with probability} \quad \frac{1}{2} \\ 2\cdot\underline{p} = 2 & \text{with probability} \quad \frac{1}{4} \end{cases}.$$

As mean and standard deviation of the compound lottery $\mathcal{L}2$ one obtains

$$\mu_2 = 6\ (= \mu_1) \quad \text{and} \quad \sigma_2 = \sqrt{8}\ (= \tfrac{\sigma_1}{\sqrt{2}}).$$

Note that lottery $\mathcal{L}1$ is a *mean-preserving spread* of lottery $\mathcal{L}2$.
As in Treatment A, subjects are asked to quote a price $b_2 \in [1, 10]$ for which they would be willing to sell the lottery $\mathcal{L}2$. The price $p \in [1, 10]$ is randomly drawn from a *uniform distribution*. For $p > b_2$, the lottery $\mathcal{L}2$ is sold and the payoff of the subject is p. For $p \leq b_2$, the lottery $\mathcal{L}2$ is played and the subject receives the lottery payout. The following diagram illustrates this scenario.

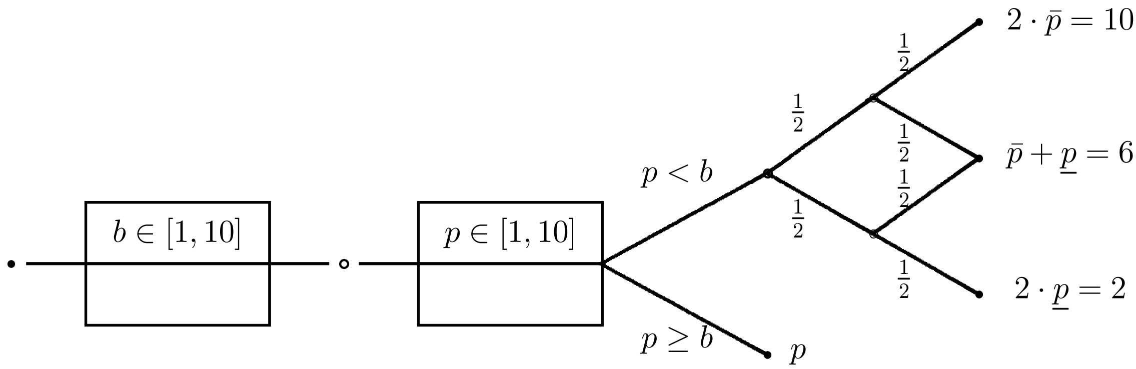

Figure 2: Treatment B

Maintaining the assumption that decision makers are expected utility maximisers, one computes easily the expected utility from a quoted price b :

$$V_2(b) := \frac{1}{4}\cdot[u(2\cdot\overline{p}) + 2\cdot u(\overline{p}+\underline{p}) + u(2\cdot\underline{p})]\cdot\frac{b-1}{9} + \frac{1}{9}\cdot\int_b^{10} u(p)\ dp.$$

$V_2(b)$ is concave if u is a strictly increasing function. The first-order conditions of the problem,

$$\text{choose} \quad b \in [1, 10] \quad \text{such that} \quad V_2(b) \quad \text{is maximised,}$$

are necessary and sufficient:

$$\frac{1}{4}\cdot[u(2\cdot\overline{p}) + 2\cdot u(\overline{p}+\underline{p}) + u(2\cdot\underline{p})] - u(b_2^*) = 0.$$

One obtains again a limit price equal to the certainty equivalent of lottery $\mathcal{L}2$,

$$\begin{aligned} b_2^* &= u^{-1}(\frac{1}{4} \cdot [u(2 \cdot \overline{p}) + 2 \cdot u(\overline{p} + \underline{p}) + u(2 \cdot \underline{p})]) \\ &= u^{-1}(\frac{1}{4} \cdot [u(10) + 2 \cdot u(6) + u(2)]). \end{aligned}$$

Comparing the optimal bids in Treatments A and B, it is not difficult to show the following properties:

- For *risk-averse* decision makers, $u(\cdot)$ *strictly concave*,
$$6 > b_2^* > b_1^* \quad \text{and} \quad V_2(b_2^*) > V_1(b_1^*)$$
follows, since $\mathcal{L}1$ is a mean-preserving spread of $\mathcal{L}2$.
- In case of *risk-neutral* decision makers, $u(x) = x$, one obtains
$$6 = b_2^* = b_1^* \quad \text{and} \quad V_2(b_2^*) = V_1(b_1^*) = 6\tfrac{8}{9}.$$
- For *risk-loving* agents, $u(\cdot)$ *strictly convex*, we have
$$6 < b_2^* < b_1^* \quad \text{and} \quad V_2(b_2^*) < V_1(b_1^*).$$

2.3 Treatment C

In Treatment C, subjects face a repeated lottery with the same payoffs as in $\mathcal{L}2$. In addition, the participants have an opportunity to sell the lottery after the first stage. The endowment of participants is the lottery

$$\mathcal{L}3 = \begin{cases} 2 \cdot \overline{p} = 10 & \text{with probability } \frac{1}{4} \\ \overline{p} + \underline{p} = 6 & \text{with probability } \frac{1}{2} \\ 2 \cdot \underline{p} = 2 & \text{with probability } \frac{1}{4} \end{cases},$$

with mean $\mu_3 = \mu_2 = \mu_1$ and standard deviation $\sigma_3 = \sigma_2 = \frac{\sigma_1}{\sqrt{2}}$.
In stage 1, the subjects quote a price $b_3 \in [1, 10]$ for which they are willing to sell the lottery. A price $p \in [1, 10]$ is then randomly drawn from a *uniform distribution*. For $p > b_3$, the lottery $\mathcal{L}3$ is sold and the payoff of the subject is p. For $p \leq b_3$, the first stage of the lottery $\mathcal{L}3$ is played.
After observing the outcome of the first stage, $\underline{p} = 1$ or $\overline{p} = 5$, respectively, owners of the lottery who have not sold the lottery in stage 1 can make a second sales offer at prices $\underline{b}_3 := b_3(\underline{p})$ or $\overline{b}_3 := b_3(\overline{p})$, respectively. Again a price $p' \in [1, 10]$ is drawn from a *uniform distribution*. For $p' > \underline{b}_3$ ($p' > \overline{b}_3$), the lottery is sold and the payoff of the subject is p'. For $p' \leq \underline{b}_3$ ($p' \leq \overline{b}_3$), the second draw of the lottery $\mathcal{L}3$ takes place and the respective payoffs are realized. Figure 3 illustrates this choice situation.
One can determine the optimal limit prices working backward. Suppose the lottery was not sold in stage 1. In **Stage 2** a limit price $b_3^*(x)$ will be determined which may depend on the previously realised result x, i.e., $\overline{p}$ or $\underline{p}$. The expected utility from quoting a price

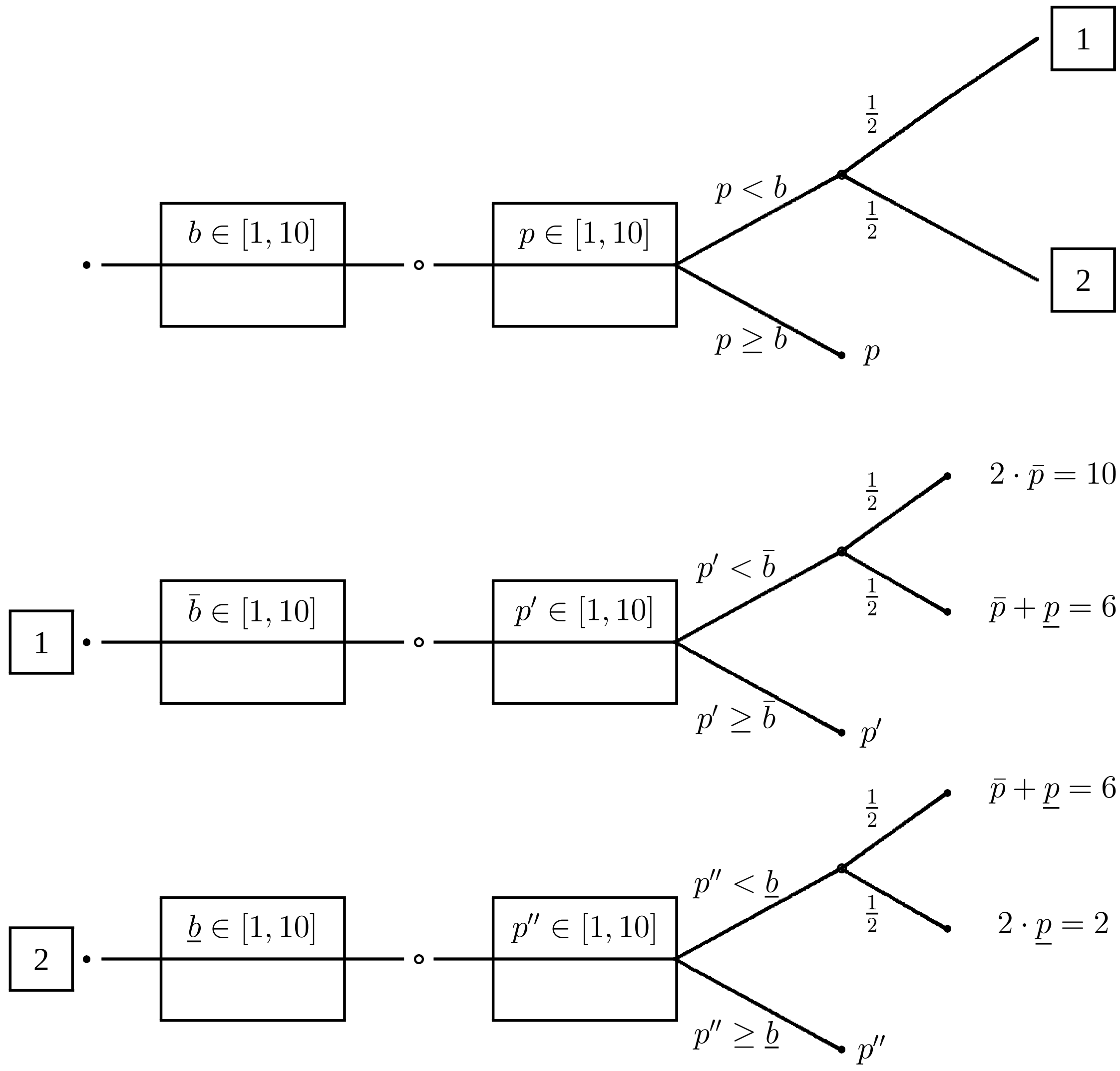

Figure 3: Treatment C

$b_3(x)$ is

$$V_3(b(x)|\, x) := \frac{1}{2} \cdot [u(x + \underline{p}) + u(x + \overline{p})] \cdot \frac{b(x) - 1}{9} + \frac{1}{9} \cdot \int_{b(x)}^{10} u(x + p)\, dp.$$

The optimisation problem,

choose $\quad b \in [1, 10] \quad$ such that $\quad V_3(b(x)|\, x) \quad$ is maximised,

yields the first-order condition

$$\frac{1}{2} \cdot [u(x + \underline{p}) + u(x + \overline{p})] - u(x + b_3^*(x)) = 0.$$

Hence,

$$\begin{aligned}
b_3^*(x) &= u^{-1}(\frac{1}{2}\cdot[u(x+\underline{p})+u(x+\overline{p})])-x \\
&= u^{-1}(\frac{1}{2}\cdot[u(x+1)+u(x+5)])-x
\end{aligned}$$

and

$$\begin{aligned}
V_3^*(x) \quad &: \quad = V_3(b_3^*(x)|\, x) \\
&= \frac{1}{2}\cdot[u(x+\underline{p})+u(x+\overline{p})]\cdot\frac{b_3^*(x)-1}{9}+\frac{1}{9}\cdot\int_{b_3^*(x)}^{10} u(x+p)\,dp \\
&= \frac{1}{2}\cdot[u(x+1)+u(x+5)]\cdot\frac{b_3^*(x)-1}{9}+\frac{1}{9}\cdot\int_{b_3^*(x)}^{10} u(x+p)\,dp.
\end{aligned}$$

Note that, for a risk-neutral participant with $u(x) = x$, the optimal bid $b_3^*(x) = 3$ is independent of x. Moreover, due to the sales option, the second-stage lottery has a value of $V_3^*(x) = x + 5\frac{13}{18}$ which is much higher than the expected value of 3 from the second-stage lottery alone.

In **Stage 1,** an expected utility maximiser will choose the limit price such that

$$V_3(b) := \frac{1}{2}\cdot[V_3^*(\underline{p})+V_3^*(\overline{p})]\cdot\frac{b-1}{9}+\frac{1}{9}\cdot\int_{b}^{10} u(p)\,dp$$

is maximised. From the first-order condition,

$$\frac{1}{2}\cdot[V_3^*(\underline{p})+V_3^*(\overline{p})]-u(b_3^*))=0,$$

one computes

$$b_3^* = u^{-1}(\frac{1}{2}\cdot[V_3^*(\underline{p})+V_3^*(\overline{p})]).$$

It is possible not to sell the second-stage lottery by bidding sufficiently high. Hence, the two-stage lottery $\mathcal{L}2$ is a choice option of the decision maker. Consequently, $b_3^* \geq b_2^*$ must be true. For a risk-neutral decision maker with $u(x) = x$, e.g., the optimal bid $b_3^* = 8\frac{13}{18}$ exceeds $b_2^* = 6$, and also lottery $\mathcal{L}3$'s certainty equivalent of 6. In fact, one can show $b_3^* > b_2^*$. This extra-value of lottery $\mathcal{L}3$ is a consequence of the additional sales option in stage 2. The following proposition summarises the comparison of bids. The proof is straight forward and omitted.

Proposition 2.1 1. If decision makers are

- *risk-averse,* then $6 > b_2^* > b_1^*$,
- *risk-neutral,* then $6 = b_2^* = b_1^*$,
- *risk-loving,* then $6 < b_2^* < b_1^*$.

2. For any attitude towards risk,

$$b_3^* > b_2^*.$$

The high optimal bids in Treatment C reflect the chances of extra profits from the sales mechanism with randomly chosen prices. Decision makers of any risk attitude will like these extra chances.

2.4 Hypotheses

Based on the assumption that decision makers are expected utility maximisers with uniform curvature of the von Neumann-Morgenstern utility index $u(\cdot)$, our theoretical analysis leads us to propose the following hypotheses :

1. *Expected utility:*
   - Either $6 > b_2^* > b_1^*$, (*risk-aversion*)
   - or $6 = b_2^* = b_1^*$, (*risk-neutrality*)
   - or $6 < b_2^* < b_1^*$. (*risk-preference*)
2. *Consistency of risk attitudes:*
   Risk attitudes do not depend on whether they are measured by
   – the difference between certainty equivalent and expected value, $b_1^* - 6 \gtreqless 0$, or
   – preferences over mean-preserving spreads, $b_1^* - b_2^* \gtreqless 0$.
3. *Valuation of flexibility:*
   The option to sell the second-stage lottery is valued extremely high.

Our experimental design should allow us to check these hypotheses. In contrast to non-expected utility theories, expected utility implies that risk-averse individuals have a certainty equivalent below the expected value of the lottery *and* a preference for less dispersed distributions in the sense of mean-preserving spreads. It will be interesting to see whether participants of the experiment will value the extra chances inherent in the sales mechanism as high as the theory predicts.

3. Experimental procedure

The experimental sessions were carried out at the Humboldt University in Berlin in January 1999. Participants were students of economics from a large first-year microeconomics course. For each session, a group of 40 students was recruited. In addition to performing the experimental task, participants were asked to fill in a questionnaire assessing their understanding of the experimental procedure. In order to control for effects due to the novelty of the situation, each treatment was repeated a second time without prior announcement.

Three groups of students participated only in a single treatment. We refer to these groups as *"between-subjects"* experiments. A fourth group of students would make decisions on all three treatments. We refer to this group as *"within-subjects"* experiments. This group offers the opportunity to study consistency of risk attitudes and behaviour across treatments.

A group of 40 students was confronted with the one-stage lottery (Treatment A). A second group of 39 students attended the experiment of Treatment B. A third group of 38 students

was subject to Treatment C.
The group of 40 participants in the "within-subject" experiment was split in two subgroups of 20 participants. For the first group of 20, earnings of all three treatments were actually paid. For the second group, the threefold earnings of one randomly selected treatment was paid out. This distinction was made in order to check whether the wide-spread practice of paying out only one randomly selected outcome would affect the participants' behaviour.

4. Results

Two types of results will be distinguished in this section. Firstly, we will deal with the question of whether the observed behaviour is consistent with theoretical predictions based on expected utility theory. These theoretical predictions were derived and formulated in three hypotheses in section 2. In a separate subsection, we will reconsider our results as to their implications for the design of decision-making experiments.

4.1 Risk attitudes and valuation of the resale option

a) Risk attitudes
Risk attitudes of expected utility maximisers can be tested either

- by comparing the certainty equivalent of a lottery with its expected value or
- by studying their preference over mean-preserving spreads.

Denote by $b(\mathbb{L})$ the certainty equivalent of lottery $\mathbb{L}$, and by $\mathbb{L}'(\mu)$ a mean-preserving spread of lottery $\mathbb{L}(\mu)$. If a decision maker's preferences satisfy the expected utility hypothesis[1], then the following preference pattern must hold:

risk attitude	*certainty equivalent*		*mean-preserving spread*
risk-averse	$\mu > b(\mathbb{L}(\mu))$	and	$b(\mathbb{L}(\mu)) > b(\mathbb{L}'(\mu))$,
risk-neutral	$\mu = b(\mathbb{L}(\mu))$	and	$b(\mathbb{L}(\mu)) = b(\mathbb{L}'(\mu))$,
risk-loving	$\mu < b(\mathbb{L}(\mu))$	and	$b(\mathbb{L}(\mu)) < b(\mathbb{L}'(\mu))$.

Moreover, $\mu > b(\mathbb{L}(\mu)) > b(\mathbb{L}'(\mu))$ for risk-averse participants, while the reverse inequalities must hold for risk-loving decision makers.
Examining the average bids for the one-stage lottery in Treatment A, we find values of 6.17 and 6.38 in the first round (Table 1) and 6.32 and 6.34 in the second round (Table 2). On first sight, this suggests that the participants were risk neutral with a slight tendency towards risk-loving behaviour.[2] This overall risk neutrality is confirmed by the results for the mode and median in this treatment. The average bids for the lotteries with a reduced variance in treatment B, their modes and medians support also this picture. Risk neutrality

[1] Note that these two indicators for the risk attitude do no longer lead to the same classification, if the decision maker's preferences do not satisfy the expected utility hypothesis.
[2] Since we elicit the willingness to accept rather than the one to pay, the fact that average bids are sightly larger than the monetary expectation of the lottery could be caused by an endowment or status quo–effect (see Samuelson and Zeckhauser, 1988).

Method	Treatm.	Mean	Median	Mode	Std.dev.	Min	Max	N
bet-	A	6.17	6.0	6.0	1.61	1.0	10.0	40
ween	B	6.10	6.0	6.0	1.24	2.9	10.0	39
subjects	C	7.31	7.5	6.0	1.35	5.0	9.9	38
with-	A	6.38	6.0	6.0	1.51	2.5	10.0	40
in	B	6.60	6.3	6.0	1.67	1.0	10.0	40
subjects	C	7.74	8.0	6.0	1.60	4.7	10.0	40

Table 1: First-round results for initial bids.

Method	Treatm.	Mean	Median	Mode	Std.dev.	Min	Max	N
bet-	A	6.32	6.0	6.0	1.87	2.7	10.0	40
ween	B	6.00	6.0	6.0	1.56	1.0	10.0	39
subjects	C	7.44	7.7	8.0	1.58	3.5	10.0	38
with-	A	6.34	6.0	6.0	1.58	3.0	10.0	40
in	B	6.28	6.0	6.0	1.40	1.0	10.0	40
subjects	C	7.37	7.25	6.0	1.60	4.0	10.0	40

Table 2: Second-round results for initial bids.

would predict a bid of exactly 6 in both treatments A and B. The null-hypothesis of equal bid distributions for treatments A and B in first-round bids of the between-subjects design cannot be rejected in a *two-tailed Mann-Whitney U-test* ($p = .917$).

This picture of a risk-neutral population of participants is put into question by the comparison of the means of bids in treatments A and B. Except for the first round of the within-subjects case, average bids are slightly higher for the more dispersed lottery in Treatment A. This indicates risk-loving behaviour. Though the exceptional within-subjects case may be viewed as suggesting a risk-averse preference for a smaller variance, a *one-tailed Wilcoxon-test* of the null-hypothesis that the bid distribution in treatment A is concentrated on lower bids than in treatment B in the first round can be rejected at the 10 percent level ($p = .074$). The comparison of treatments A and B supports the view of a slightly risk-loving population of participants.

The slightly conflicting assessment of the participants' risk attitudes, depending on whether the risk attitude is measured by divergence of the certainty-equivalent bid from the expected value of the lottery or by the preferences over mean-preserving spreads, suggests a closer look at the risk attitudes displayed in the choices of treatments A and B.

b) Consistency of risk attitudes

In order to gain more insight into the participants' risk attitudes, we classify the risk attitude of participants in the within-subjects design according to the certainty-equivalent bid *and* according to their preferences over mean-preserving spreads. When investigating how many participants were consistent in their risk attitudes, we do not want to rely on small numerical variations in the bids but on rather broad classifications. We will classify a decision maker as risk neutral if the bid in Treatment A, $b(A)$, falls into an interval $[\mu - 0.5, \mu + 0.5]$. Similarly, a subject submitting a bid in Treatment B, $b(B)$, in the interval of 0.5 around $b(A)$, $[b(A) - 0.5, b(A) + 0.5]$, will be classified as risk-neutral. The deviation of ± 0.5 corresponds to approximately 6 percent of the total variation of payoffs. The following table summarises this classification.

risk averse	*risk neutral*	*risk loving*
$b(A) < 5.5$	$5.5 \leq b(A) \leq 6.5$	$6.5 < b(A)$
$b(B) > b(A) + 0.5$	$b(A) - 0.5 \leq b(B) \leq b(A) + 0.5$	$b(B) < b(A) - 0.5$

A cross tabulation according to this classification for both groups of the participants in

		preferences for diversification			
		risk averse	*risk neutral*	*risk loving*	N
certainty-	*risk averse*	0	3	9	12
equivalent	*risk neutral*	1	10	2	13
based	*risk loving*	4	10	1	15
	N	5	23	12	40

Table 3: Cross tabulation of risk attitude classifications: first round

the within-subjects treatments is given in Tables 3 and 4. Table 3 tests the consistency of the measurement of risk attitudes in the first round of the within-subjects case.
About one third of the participants will be ranked as risk averse according to a certainty-equivalent bid below the expected value but only five participants were considered as risk averse based on their preference for greater diversification. In general, the preference for the more risky lottery was stronger than the ranking according to the certainty-equivalent bid would suggest.
Most striking is the fact that only a quarter of the participants (11 subjects) were ranked consistently by the two measures. A surprisingly large number of subjects (9 participants) had a certainty-equivalent bid below the expected value of the lottery but did strictly prefer the riskier lottery in Treatment A. This casts doubt on whether the two measures of uncertainty aversion capture the same behaviour.
Table 4 cross tabulates the classification of risk preferences according to preference for diversification and according to the certainty equivalent for the second round of the within-subjects treatment.
The second round shows a more consistent picture. Over 50 percent of the group (21 subjects) are now ranked the same way by the two measures. Moreover, the extremely inconsistent behaviour of risk-averse subjects according to the certainty-equivalent bid preferring the riskier lottery has nearly disappeared. This could be interpreted as if subjects would need some experience with the treatment before understanding completely the implications of the scenario.
The effect of experience is also reflected in significantly lower bids in the repetition of treatments B and C for the pooled data of the within-subjects design ($p = .049$ for Treatment B and $p = .0295$ for first-stage bids in Treatment C in a *one-tailed Wilcoxon-test*.).
Consistency of the two measures for attitudes toward risk requires some understanding of the concept of a mean-preserving spread. Consistency over the two rounds in terms of certainty-equivalent bids does not rely on such skills. This consistency can also be tested

		preferences for diversification			
		risk averse	*risk neutral*	*risk loving*	N
certainty-	*risk averse*	5	5	1	11
equivalent	*risk neutral*	2	12	1	15
based	*risk loving*	0	10	4	14
	N	7	27	6	40

Table 4: Cross tabulation of risk attitude classifications: second round

		second round			
		risk averse	*risk neutral*	*risk loving*	N
first round	*risk averse*	5	3	3	11
	risk neutral	5	8	2	15
	risk loving	1	2	11	14
	N	11	13	16	40

Table 5: Cross tabulation of risk attitude in Treatment A: first vs second round

for the between-subjects treatments.

Consider first the between-subjects results of Treatment A (see Table 5). In this case, 60 percent of the participants (24 subjects) are consistent in their attitudes towards risk. The dominant risk attitude appears to be risk-loving behaviour. In Treatment B, the degree of consistency is even greater. In contrast to Treatment A however, 50 percent of the participants can be ranked as risk-neutral (see Table 6).

c) Preference for resale option

In Treatment C, decision makers could sell the second stage of their lottery, if they had not sold the whole lottery in stage 1. Though this lottery resembles the one in Treatment B, the experimental results shows a completely different picture. Due to the second sale option after stage 1, decision makers could profit twice from randomly chosen prices. Our theoretical considerations in section 2 suggest that decision makers will value high the extra option to sell. Indeed, for all types of risk preferences, the first bid in Treatment C should exceed the bid in Treatment B. In the case of risk neutrality, the first bid should be as high as 8.7.

Indeed, the experimental results show high first-stage bids in Treatment C. While the average bid was close to 6 in treatments A and B, it was between 7.31 and 7.74 in Treatment C (Table 1). The median was similarly upward biased, while the mode remained at the expected value $\mu = 6$. This suggests a strong positive valuation for the additional sales option.

These observations are confirmed by statistical tests of the null hypothesis of higher bids in Treatment C. In the first round of Treatment C, the distribution of first-stage bids is significantly more concentrated on higher bids than in the first rounds of treatments A and B. Using a *one-tailed Mann-Whitney U-test* for the between-subjects data yields $p = .0005$ for Treatment C vs. Treatment A and $p < .001$ for treatment C vs. Treatment B. For the within-subjects data, a *one-tailed Wilcoxon-test* resulted also in $p < .001$ both for Treatment C vs. Treatment A and for Treatment C vs. Treatment B.

		second round			
		risk averse	*risk neutral*	*risk loving*	N
first round	*risk averse*	6	0	1	7
	risk neutral	2	19	3	24
	risk loving	0	2	6	8
	N	8	21	10	39

Table 6: Cross tabulation of risk attitude in Treatment B: first vs second round

Round	Method	Type of bid	Mean	Median	Mode	Std.dev.	Min	Max	N
1st	*between*	$\overline{b}_3$	4.14	4.7	5.0	1.33	1.0	6.0	14
	subjects	$\underline{b}_3$	4.74	4.9	3.0	1.52	2.5	7.5	15
	within	$\overline{b}_3$	5.56	5.0	4.0	2.05	3.0	10.0	16
	subjects	$\underline{b}_3$	4.75	5.0	5.0	1.65	1.0	8.2	24
2nd	*between*	$\overline{b}_3$	3.94	4.0	3.0	1.54	1.1	6.6	16
	subjects	$\underline{b}_3$	3.86	4.0	5.0	1.21	2.4	5.0	8
	within	$\overline{b}_3$	4.89	5.0	5.0	1.83	1.0	7.49	14
	subjects	$\underline{b}_3$	5.97	5.5	5.0	1.99	3.0	10.0	12

Table 7: Second-stage bids in treatment C.

	competence level								
	4	3	2	1	0	-1	-2	-3	-4
Treatment A	1	–	0.7	0	0.43	1	0.4	–	0
Treatment B	0.84	–	0.8	0.75	1	1	0.8	$.5$	0
Treatment C	–	0.75	1	0.93	1	1	1	0.5	–

Table 8: Competence of participants.

Probably the most surprising feature of the results are, however, the bids in the second stage of Treatment C. Table 7 shows mean bids ranging from 4.14 to 5.97. In the second-stage lottery the expected value equals 3 and the maximum payout from the lottery was 5. The summary statistics in Table 7 suggest an extremely risk-loving attitude towards risk. The frequency distributions show bids up to 10, double the maximum outcome of the lottery. Such behaviour is inconsistent with expected utility theory, in fact with any decision-theory which is purely consequentialist. In order to explain bids which exceed the maximum payoff of a lottery, a decision maker has to have an intrinsic preference for gambling.

Of course, participants who did not sell in stage 1 were those with the highest bids in period 1. Thus, there is a selection bias towards more risk-loving participants. Hence, it should not surprise to find more risk-loving behaviour in the group of second-stage bidders. Yet, bidding more than the maximum amount that could be obtained in the second-stage lottery cannot be reconciled with standard decision theories which insist on valuing only outcomes.

The results of Table 7 reveal no clear wealth effect. A one-sided Wilcoxon test of the null hypothesis of a higher bid distribution after a low payoff $\underline{p}$ is not supported by the data. There is also no hint of the "gambler's effect" of an increased expectation of a high outcome in consequence of a low outcome in stage 1.

d) Competence of participants

The discrepancies in the risk preferences of participants when measured by certainty equivalents or preferences over mean-preserving spreads suggest to check the answers to the questionnaires in order to see whether participants did understand the implications of the different lotteries. The questionnaire posed four questions related to the outcome of the lottery and the payoff obtainable from a bid for two results of the draws in the lottery and from the price distribution. Competence of the participant was measured by the sum of the scores of the four questions, where a correct answer was given a mark of 1, a false answer a mark of -1, and no answer was given 0.

Table 8 shows the relationship between competence levels between 4, all answers were correct, and -4, no answer was correct, and the percentage of subjects within the same competence group who were consistent in their risk attitudes across rounds.

Table 8 shows only a slight positive relationship between the degree of understanding of the lotteries and of the sales mechanism and the degree of consistency in risk attitudes. We conclude from this that incompetence about the lotteries and the sales mechanism cannot account for the observed inconsistencies in the classification of risk attitudes.

4.2 Methodological issues

Several implications for the design of experiments can be drawn from our observations.
a) Between- vs within-subjects data
Do participants react significantly to *"method"*, i.e. to be confronted with only one task (A, B, or C) or to all three tasks? When testing this hypothesis we rely on the pooled data of the within-subjects design. At the one-percent level homogeneity of the between-subjects and the within-subjects distributions cannot be rejected for treatments A, B, and (first-stage bids) C. At the five-percent level the (on average negative) difference of first-round bids in treatment B when comparing between- with within-subjects data is significant. In our view, such weak confirmation for one of the altogether six comparisons should not be overrated. Whatever can be learned from our data is supported by both, the between-subjects and the within-subjects data.
b) Effect of random payout
In the within-subjects experiments, half of the 40 participants (group 1) were paid for all three tasks whereas the other half was paid only for one randomly selected task A, B, or C. To provide similar monetary incentives for these groups, the randomly selected payoff was tripled.
Comparing the bid distributions of first- and second-round bids in case of treatment A reveals only one weak ($p = .049$) effect in case of first-stage bids in the first round of treatment C. In our view, such a weak effect for one of altogether eight comparisons (we have pooled the second-period bids $\overline{b}_3$ and $\underline{b}_3$ in treatment C) does not question our former analysis which disregarded the different payment regimes in case of treatment C and the within-subject design (see CUBITT, STARMER, AND SUGDEN, 1998, who report positive effects of deterministic versus stochastic payment for a different, but related task).
c) The random price mechanism for eliciting certainty equivalents
In a recent study, BOHM, LINDEN, AND SONNEGARD (1997) found that the BDM mechanism is sensitive to the support of the price distribution. In particular, the maximum price possible appears to be important for the results of the mechanism. To avoid such effects in our experiment, the random price p' in stage 2 of Treatment C was selected from the same interval $[1, 10]$ as the price p in stage 1. The extreme overbidding observed in stage 2 of Treatment C may be an unintended consequence of this design choice. Retrospectively, it appears possible that the fact that a price of 10 was possible in stage 2 may have biased upward the bids of the participants. Such a bias may, of course, have influenced also bids in the other treatments.

5. Concluding remarks

We can summarise our main findings by the following effects:

1. Subjects show *risk-neutrality or risk-loving* behaviour.
2. *Consistency in risk attitudes* across repetitions and for different measures of risk attitudes *is limited.*
3. Subjects show a *strong preference for a second sale option.*

4. *Subjects bid unreasonably high in second sale.*

A noticeable result of our experiment is the observation that, in this simple lottery context, the behaviour of most participants appears to be consistent with expected utility theory and risk-loving or risk-neutral preferences. It is also consistent with expected utility theory that bids in stage 1 of Treatment C were significantly higher than bids in Treatment B. In these respects expected utility theory appears to be sufficiently flexible to explain these observations.

Other results of our experiment are harder to reconcile with expected utility theory. For example, the overbidding in stage 2 of Treatment C is incompatible not only with expected utility theory but with any purely consequentialist explanation.

There are, of course, competing explanations for some of our observations. The risk-loving behaviour could also be explained by an endowment effect. Inconsistency in the risk preferences across treatments could be due to people who are variety seeking not only in consumption, but also in risk taking. The unreasonable high bids in stage 2 of Treatment C may be a consequence of the sensitivity of the random price mechanism to the maximum price in the random price distribution.

Altogether it is promising to continue this research, e.g. by collecting larger sets of decision data and by allowing for more experience. However, this would mean to perform an experiment with many repetitions, but to pay only one randomly selected round. Otherwise a repeated experiment might be seen as offering the same chances as our Treatment B as compared to Treatment A.

Appendix

A.1 Instructions

1. Treatment A

ANLEITUNG A
Willkommen zu unserem Experiment! Bitte lesen Sie diese Anleitung sorgfältig durch! Sprechen Sie nicht mit Ihren Nachbarn und behalten Sie Ruhe während des gesamten Experiments! Falls Sie Fragen haben, melden Sie sich! Wir kommen dann zu Ihnen.
In diesem Experiment werden Sie einige wenige Entscheidungen zu treffen haben. Wieviel Geld Sie hierdurch endgültig verdienen, hängt nur von Ihren eigenen Entscheidungen sowie von Zufallsereignissen ab.
Sie haben die Möglichkeit an einer Lotterie teilzunehmen, die in den Perioden 1 und 2 entweder DM 5.00 oder DM 1.00 auszahlt. Wie wird entschieden, welche der Auszahlungen die Lotterie in den beiden Perioden generiert ?
Sie werden dazu einmal würfeln:

- Sie gewinnen in Periode 1 und 2 jeweils DM 5.00, wenn Sie eine gerade Augenzahl würfeln.
- Sie gewinnen in Periode 1 und 2 jeweils DM 1.00, wenn Sie eine ungerade Augenzahl würfeln.

Sie können nun diese Lotterie behalten und an ihr teilnehmen oder sie an uns (die Experimentatoren) verkaufen.
Wie können Sie die Lotterie verkaufen, falls Sie dies wollen?
Dazu müssen Sie eine untere Preisschranke b festlegen (b mu zwischen DM 1.00 und DM 10.00 liegen). Sie verkaufen dann die Lotterie zu einem zufällig ausgewählten Preis p, falls p größer als Ihre Preisschranke b ist. Anderenfalls behalten Sie die Lotterie und nehmen an ihr teil. Der Preis p wird zufällig im Bereich aller Preise von

DM 1.10, DM 1.20, . . . , DM 9.90, DM 10.00 $\qquad (*)$

ausgewählt.
Bitte beachten Sie, daIhre Preisschranke b nicht den Preis p festlegt, zu dem Sie die Lotterie verkaufen, sondern nur das Intervall ($b < p \leq$ DM 10.00) der Preise p, zu denen Sie zum Verkauf der Lotterie bereit sind. Die für Sie beste Preisschranke b ist damit der Preis p, bei dem Ihnen Verkauf und Nichtverkauf der Lotterie als gleich günstig erscheinen.
Beachten Sie weiterhin, daSie durch die Wahl von $b =$ DM 10.00 sicherstellen können, da Sie die Lotterie, egal welcher Preis p zufällig ausgewählt wird, stets behalten. Durch die Wahl von $b =$ DM 1.00 können Sie hingegegen sicherstellen, daSie die Lotterie in jedem Fall verkaufen.
Zum besseren Verständnis der Regeln, wird im folgenden noch einmal die Abfolge der Ereignisse genau aufgelistet:

1. Sie legen Ihre untere Preisschranke b fest.
(Wie oben erläutert, ist dies die Preisschranke, oberhalb derer Sie bereit sind, die Lotterie an uns zu verkaufen.)
2. Der Preis p wird zufällig ausgewählt.
(Zu diesem Zweck wird in eine Urne mit Chips gegriffen, auf denen die Preise p wie unter $(*)$ stehen.)
3. Falls $p > b$, verkaufen Sie die Lotterie an uns. Ihre Auszahlung beträgt in diesem Fall DM p.
4. Falls $p \leq b$, behalten Sie die Lotterie und nehmen an ihr teil. Diese wird dann ausgespielt, indem Sie einmal würfeln. In diesem Fall erhalten Sie die Auszahlung der Lotterie wie oben beschrieben.

Die Entscheidung erfolgt auf einem separaten Formular, das wir gleich an alle Teilnehmer austeilen.
Sie bekommen eine Codenummer, damit Ihre Anonymität uns gegenüber erhalten bleibt. Ihre Codekarte heben Sie bitte gut auf, denn nur gegen ihre Vorlage werden Sie später Ihre Auszahlung erhalten.

2. Treatment B

ANLEITUNG B

Willkommen zu unserem Experiment! Bitte lesen Sie diese Anleitung sorgfältig durch! Sprechen Sie nicht mit Ihren Nachbarn und behalten Sie Ruhe während des gesamten Experiments! Falls Sie Fragen haben, melden Sie sich! Wir kommen dann zu Ihnen.

In diesem Experiment werden Sie einige wenige Entscheidungen zu treffen haben. Wieviel Geld Sie hierdurch endgültig verdienen, hängt nur von Ihren eigenen Entscheidungen sowie von Zufallsereignissen ab.

Sie haben die Möglichkeit an einer Lotterie teilzunehmen, die in den Perioden 1 und 2 entweder DM 5.00 oder DM 1.00 auszahlt. Wie wird entschieden, welche der Auszahlungen die Lotterie in den beiden Perioden generiert ?

Sie werden dazu zweimal hintereinander würfeln.

Sie gewinnen jeweils DM 5.00, wenn Sie eine gerade Augenzahl würfeln.

- Sie gewinnen jeweils DM 1.00, wenn Sie eine ungerade Augenzahl würfeln.
- Sie können nun diese Lotterie behalten und an ihr teilnehmen oder sie an uns (die Experimentatoren) verkaufen.

Wie können Sie die Lotterie verkaufen, falls Sie dies wollen?

Dazu müssen Sie eine untere Preisschranke b festlegen (b mu zwischen DM 1.00 und DM 10.00 liegen). Sie verkaufen dann die Lotterie zu einem zufällig ausgewählten Preis p, falls p grö er als Ihre Preisschranke b ist. Anderenfalls behalten Sie die Lotterie und nehmen an ihr teil. Der Preis p wird zufällig im Bereich aller Preise von

DM 1.10, DM 1.20, . . . , DM 9.90, DM 10.00 $(*)$

ausgewählt.

Bitte beachten Sie, daIhre Preisschranke b nicht den Preis p festlegt, zu dem Sie die Lotterie verkaufen, sondern nur das Intervall ($b < p \leq$ DM 10.00) der Preise p, zu denen Sie zum Verkauf der Lotterie bereit sind. Die für Sie beste Preisschranke b ist damit der Preis p, bei dem Ihnen Verkauf und Nichtverkauf der Lotterie als gleich günstig erscheinen.

Beachten Sie weiterhin, daSie durch die Wahl von $b =$ DM 10.00 sicherstellen können, da Sie die Lotterie, egal welcher Preis p zufällig ausgewählt wird, stets behalten. Durch die Wahl von $b =$ DM 1.00 können Sie hingegegen sicherstellen, daSie die Lotterie in jedem Fall verkaufen.

Zum besseren Verständnis der Regeln, wird im folgenden noch einmal die Abfolge der Ereignisse genau aufgelistet:

1. Sie legen Ihre untere Preisschranke b fest.
   (Wie oben erläutert, ist dies die Preisschranke, oberhalb derer Sie bereit sind, die Lotterie an uns zu verkaufen.)
2. Der Preis p wird zufällig ausgewählt.
   (Zu diesem Zweck wird in eine Urne mit Chips gegriffen, auf denen die Preise p wie unter $(*)$ stehen.)
3. Falls $p > b$, verkaufen Sie die Lotterie an uns. Ihre Auszahlung beträgt in diesem Fall DM p.
4. Falls $p \leq b$, behalten Sie die die Lotterie und nehmen an ihr teil. Diese wird dann ausgespielt, indem Sie zweimal hintereinander würfeln. In diesem Fall erhalten Sie die Auszahlung der Lotterie wie oben beschrieben.

Die Entscheidung erfolgt auf einem separaten Formular, das wir gleich an alle Teilnehmer austeilen.

Sie bekommen eine Codenummer, damit Ihre Anonymität uns gegenüber erhalten bleibt. Ihre Codekarte heben Sie bitte gut auf, denn nur gegen ihre Vorlage werden Sie später Ihre Auszahlung erhalten.

3. Treatmant C

ANLEITUNG C

Willkommen zu unserem Experiment! Bitte lesen Sie diese Anleitung sorgfältig durch! Sprechen Sie nicht mit Ihren

Nachbarn und behalten Sie Ruhe während des gesamten Experiments! Falls Sie Fragen haben, melden Sie sich! Wir kommen dann zu Ihnen.
In diesem Experiment werden Sie einige wenige Entscheidungen zu treffen haben. Wieviel Geld Sie hierdurch endgültig verdienen, hängt nur von Ihren eigenen Entscheidungen sowie von Zufallsereignissen ab.
Sie haben die Möglichkeit an einer Lotterie teilzunehmen, die in den Perioden 1 und 2 entweder DM 5.00 oder DM 1.00 auszahlt. Wie wird entschieden, welche der Auszahlungen die Lotterie in den beiden Perioden generiert ?
Sie werden dazu zweimal hintereinander würfeln.

- Sie gewinnen jeweils DM 5.00, wenn Sie eine gerade Augenzahl würfeln.
- Sie gewinnen jeweils DM 1.00, wenn Sie eine ungerade Augenzahl würfeln.

Sie können nun diese Lotterie behalten und an ihr teilnehmen oder sie an uns (die Experimentatoren) verkaufen.
Wie können Sie die Lotterie verkaufen, falls sie dies wollen?
Sie können zunächst die gesamte Lotterie verkaufen. Dazu müssen Sie eine untere Preisschranke b festlegen (b mu zwischen DM 1.00 und DM 10.00 liegen). Sie verkaufen dann die gesamte Lotterie zu einem zufällig ausgewählten Preis p, falls p größer als Ihre Preisschranke b ist. Anderenfalls behalten Sie die Lotterie und nehmen am ersten Würfeln teil. Der Preis p wird zufällig im Bereich aller Preise von

DM 1.10, DM 1.20, . . . , DM 9.90, DM 10.00 (∗)

ausgewählt.
Haben Sie die gesamte Lotterie nicht verkauft, so können Sie nach dem ersten Würfeln, nochmals, Ihre Gewinnansprüche aus dem zweiten Würfeln verkaufen. Dies läuft genau nach den gleichen Regeln wie oben ab.
Bitte beachten Sie, daIhre Preisschranke b nicht den Preis p festlegt, zu dem Sie die gesamte Lotterie (bzw. Ihre Gewinnansprüche aus dem zweiten Würfeln) verkaufen, sondern nur das Intervall ($b < p \leq$ DM 10.00) der Preise p, zu denen Sie zum Verkauf der gesamten Lotterie (bzw. zum Verkauf Ihrer Gewinnansprüche aus dem zweiten Würfeln) bereit sind. Die für Sie beste Preisschranke b ist damit der Preis p, bei dem Ihnen Verkauf und Nichtverkauf als gleich günstig erscheinen.
Beachten Sie weiterhin, daSie jeweils durch die Wahl von $b =$ DM 10.00 sicherstellen können, da Sie Ihre Gewinnansprüche aus jedem Würfeln, egal welcher Preis p zufällig ausgewählt wird, stets behalten. Durch die Wahl von $b =$ DM 1.00 können Sie hingegen sicherstellen, da Sie die gesamte Lotterie (bzw. Ihre Gewinnansprüche aus dem zweiten Würfeln) in jedem Fall verkaufen.
Zum besseren Verständnis der Regeln, wird im folgenden noch einmal die Abfolge der Ereignisse genau aufgelistet:

1. Sie legen Ihre untere Preisschranke b für die gesamte Lotterie fest.
   (Wie oben erläutert, ist dies die Preisschranke, oberhalb derer Sie bereit sind, die gesamte Lotterie an uns zu verkaufen.)
2. Ein Preis p wird zufällig ausgewählt.
   (Zu diesem Zweck wird in eine Urne mit Chips gegriffen, auf denen die Preise p wie unter (∗) stehen.)
3. Falls $p > b$, verkaufen Sie die gesamte Lotterie an uns. Ihre Auszahlung beträgt in diesem Fall DM p und das Experiment endet.
4. Falls $p \leq b$, behalten Sie die Lotterie und das Experiment wird fortgesetzt. Die erste Periode der Lotterie wird dann ausgespielt, indem Sie einmal würfeln. Die entsprechenden Auszahlungen sind Ihre Gewinne aus der ersten Periode.
5. Sie können nun Ihre Gewinnansprüche aus dem zweiten Würfeln verkaufen, in dem Sie nun nochmals eine untere Preisschranke b festlegen.
6. Ein zweiter Preis p wird zufällig bestimmt.

7. Falls $p > b$, verkaufen Sie Ihre Gewinnansprüche aus dem zweiten Würfeln an uns. Ihre Auszahlung beträgt in diesem Fall DM p zuzüglich Ihrer Gewinne in der ersten Periode.
8. Falls $p \leq b$, behalten Sie die Gewinnansprüche aus dem zweiten Würfeln. Die zweite Periode der Lotterie wird dann ausgespielt, indem Sie nochmals würfeln. Ihre Auszahlung ist dann die Summe der entsprechenden Gewinne aus dem ersten und dem zweiten Würfeln.

Die Entscheidung(en) erfolgt auf einem separaten Formular, das wir gleich an alle Teilnehmer austeilen.
Sie bekommen eine Codenummer, damit Ihre Anonymität uns gegenüber erhalten bleibt. Ihre Codekarte heben Sie bitte gut auf, denn nur gegen ihre Vorlage werden Sie später Ihre Auszahlung erhalten.

4. English Translation

Instructions for Treatment A [B]:
Welcome to our experiment! Please read these instructions carefully! Do not talk to your neighbours and keep quiet during the entire experiment. If you have a question, give notice. We will then come to you.
In this experiment you will have to make a few decisions. How much money you will finally earn depends on your own decisions as well as on chance moves.
You have the opportunity to participate in a lottery which pays in periods 1 and 2 either DM 5.00 or DM 1.00. How is decided which of the payoffs the lottery generates in both periods?
You will throw a die once [twice].

- You win in period 1 and 2 DM 5.00 if the die shows an even number.
  [You win DM 5.00 each time the die shows an even number.]
- You win in period 1 and 2 DM 1.00 if the die shows an odd number.
  [You win DM 1.00 each time the die shows an odd number.]

You can now keep the lottery and participate in it or you can sell it to us (the experimenters).
How can you sell the lottery, in case you want to?
For this purpose you have to determine a lower price limit b (b has to lie between DM 1.00 and DM 10.00). You will sell the lottery at a randomly chosen price p, if p is larger than your price limit b. Otherwise you will keep the lottery and participate in it. The price p will be randomly selected from the set of all prices:

$$DM1.10, DM1.20, ..., DM9.90, DM10.00. \qquad (*)$$

Please note that your price limit b does not determine the price at which you sell the lottery but the interval ($b < p \leq$ DM 10.00) of prices p, for which you are willing to sell the lottery. Therefore, the price limit optimal for you is the price p, at which selling and not selling the lottery appears equally favourable.
Please note further that by choosing $b =$ DM 10.00 you can ensure keeping the lottery independent of the randomly drawn price. In contrast to this you can ensure to sell the lottery in any case by the choice of $b =$ DM 1.00.
For a better understanding of the rules the sequence of events is listed again:

1. You determine your lower price limit b.

   (As explained above, this is the price limit above which you are willing to sell the lottery to us.)
2. The price p is randomly selected.

   (For this purpose, somebody will grab into a bowl with chips. The chips carry the prices listed under $(*)$.)

3. If $p > b$, you will sell the lottery to us. In this case your payoff will be DM p.
4. If $p \leq b$, you will keep the lottery and participate in it. It will be played by you by throwing the die once [twice]. In this case you will receive the payoff of the lottery as described above.

The decision is made on a separate form, which we will soon hand out to all participants.
You will receive a code-number to keep your anonymity towards us. Please keep your code-card carefully, because you will later receive your payment only when presenting it.

Instructions for Treatment C.
Welcome to our experiment! Please read these instructions carefully! Do not talk to your neighbours and keep quiet during the entire experiment. If you have a question, give notice. We will then come to you.
In this experiment you will have to make a few decisions. How much money you will finally earn depends on your own decisions as well as on chance moves.
You have the opportunity to participate in a lottery which pays in periods 1 and 2 either DM 5.00 or DM 1.00. How is decided which of the payoffs the lottery generates in both periods?
You will throw a die twice.

- You win DM 5.00 each time the die shows an even number.
- You win DM 1.00 each time the die shows an odd number.

You can now keep the lottery and participate in it or you can sell it to us (the experimenters).
How can you sell the lottery, in case you want to?
In the first place you can sell the lottery as a whole. To do this you have to determine a lower price limit b (b has to lie between DM 1.00 and DM 10.00). You will sell the entire lottery at a randomly chosen price p, if p is larger than your price limit b. Otherwise you will keep the lottery and participate in it by throwing the die once. The price p will be randomly selected from the set of all prices:

$$DM1.10, DM1.20, ..., DM9.90, DM10.00. \qquad (*)$$

If you have not sold the entire lottery, you can again sell your payoff claims from the second throw of the die. This follows according to the same procedure as above.
Please note that your price limit b does not determine the price at which you sell the entire lottery (respectively your payoff claims from the second throw of the die), but the interval ($b < p \leq$ DM 10.00) of prices p, for which you are willing to sell the entire lottery (respectively your payoff claims from the second throw of the die). Therefore, the price limit optimal for you is the price p, at which selling and not selling the lottery appears equally favourable.
Please note further that by choosing $b =$ DM 10.00 you can ensure keeping your payoff claims from each throw of the die independent of the randomly drawn price. In contrast to this you can ensure to sell the entire lottery (respectively your payoff claims from the second throw of the die) in any case by the choice of $b =$ DM 1.00.
For a better understanding of the rules the sequence of events is listed again:

1. You determine your lower price limit b for the entire lottery.

   (As explained above, this is the price limit above which you are willing to sell the entire lottery to us.
2. The price p is randomly selected.
   (For this purpose, somebody will grab into a bowl with chips. The chips carry the prices as listed under $(*)$.)
3. If $p > b$, you will sell the entire lottery to us. In this case your payoff will be DM p and the experiment ends.
4. If $p \leq b$, you will keep the lottery and participate in it and the experiment will be continued. The first period of the lottery will be played by you by throwing the die once. The respective payoff is your profit of the first period.

5. You can now sell your payoff claims from the second throw of the die by again determining a lower price limit b.
6. A second price p is randomly determined.
7. If $p > b$ you will sell your payoff claims from the second throw of the die. In this case your payment is DM p plus your profits from the first period.
8. If $p \leq b$ you will keep your payoff claims from the second throw of the die. The second period of the lottery is then played by you throwing the die again. Your payment is then the sum of the respective profits from the first and the second throw of the die.

The decision(s) are made on a separate form, which we will soon hand out to all participants. You will receive a code-number to keep your anonymity towards us. Please keep your code-card carefully, because you will later receive your payment only when presenting it.

A.2 Data

1. Between-subjects treatments

Treatment A

subject	first round bid	second round bid
1	5.00	6.00
2	8.00	6.00
3	7.90	7.50
4	5.50	5.50
5	6.00	6.00
6	5.40	6.80
7	7.99	7.99
8	4.90	10.00
9	5.00	5.00
10	4.00	3.00
a-11	1.00	10.00
a-12	7.50	7.50
a-13	8.00	8.00
a-14	6.00	6.00
a-15	7.00	5.00
a-16	5.50	4.50
a-17	8.00	8.00
a-18	6.90	6.90
a-19	6.00	5.00
a-20	4.50	3.20
a-21	7.00	5.60
a-22	5.50	5.00
a-23	6.00	6.00
a-24	6.50	7.50
a-25	3.50	6.30
a-26	5.50	5.50
a-27	6.00	2.70
a-28	6.00	9.50
a-29	9.00	8.00
a-30	7.49	7.40
a-31	5.00	6.00
a-32	5.90	5.90
a-33	5.00	4.00
a-34	5.00	5.00
a-35	6.80	7.20
a-36	6.00	6.00
a-37	6.40	6.40
a-38	8.00	8.00
a-39	10.00	10.00
a-40	6.00	3.00

Treatment B

subject	first round bid	second round bid
1	10.00	10.00
2	5.00	5.00
4	6.00	6.00
5	6.50	7.00
6	6.00	6.00
7	6.00	6.00
8	6.00	6.00
9	6.00	5.00
10	4.00	4.50
b-11	4.90	1.00
b-12	8.00	6.00
b-13	6.00	6.00
b-14	6.10	6.10
b-15	8.00	6.00
b-16	5.99	5.99
b-17	6.00	6.00
b-18	2.90	3.00
b-19	6.00	6.00
b-20	6.00	6.00
b-21	6.00	6.00
b-22	5.90	5.90
b-23	6.00	6.00
b-24	7.00	7.00
b-25	6.10	3.90
b-26	4.00	4.00
b-27	6.00	6.00
b-28	6.00	10.00
b-29	8.00	8.00
b-30	6.70	7.20
b-31	5.10	7.00
b-32	5.50	5.50
b-33	5.00	5.00
b-34	5.90	5.90
b-35	5.90	5.90
b-36	6.00	6.00
b-37	5.90	6.00
b-38	8.40	7.50
b-39	6.00	7.00
b-40	7.00	6.70

Treatment C

	first round				second round			
subject	bid 1	prize 1	bid 2	prize 2	bid 1	prize 1	bid 2	prize 2
c-1	6.10	-	-	-	6.10	-	-	-
c-2	7.00	-	-	-	7.90	-	-	-
c-4	5.90	-	-	-	8.90	-	-	-
c-5	6.91	-	-	-	7.39	-	-	-
c-6	8.50	$\underline{p}$	7.40	$\underline{p}$	8.50	-	-	-
c-7	6.90	-	-	-	8.00	-	-	-
c-8	6.00	-	-	-	6.00	-	-	-
c-9	6.00	-	-	-	5.00	-	-	-
c-10	9.00	$\overline{p}$	5.00	$\overline{p}$	7.00	-	-	-
c-11	9.90	$\overline{p}$	1.00	S	9.90	$\overline{p}$	1.80	S
c-12	6.00	-	-	-	6.50	-	-	-
c-13	8.00	$\overline{p}$	4.00	$\underline{p}$	8.00	-	-	-
c-14	8.00	$\overline{p}$	5.00	$\overline{p}$	8.00	-	-	-
c-15	8.50	$\overline{p}$	5.00	$\underline{p}$	7.50	-	-	-
c-16	6.00	-	-	-	6.00	-	-	-
c-17	8.00	$\underline{p}$	4.40	$\underline{p}$	10.00	$\underline{p}$	2.40	$\overline{p}$
c-18	6.00	$\overline{p}$	3.00	S	6.00	$\underline{p}$	3.00	$\overline{p}$
c-19	8.60	$\underline{p}$	4.50	$\underline{p}$	7.50	$\overline{p}$	6.60	$\overline{p}$
c-20	8.00	$\overline{p}$	4.00	$\overline{p}$	8.00	$\overline{p}$	4.00	$\overline{p}$
c-21	8.50	$\overline{p}$	4.50	$\underline{p}$	8.50	$\overline{p}$	5.00	$\overline{p}$
c-22	6.00	$\underline{p}$	3.00	S	6.00	$\overline{p}$	3.00	$\overline{p}$
c-23	7.50	$\underline{p}$	7.50	$\overline{p}$	7.50	$\overline{p}$	4.00	$\overline{p}$
c-24	5.00	$\overline{p}$	5.00	$\underline{p}$	5.00	$\underline{p}$	5.00	$\underline{p}$
c-25	5.10	$\overline{p}$	4.90	$\underline{p}$	5.20	$\overline{p}$	1.10	S
c-26	7.50	$\overline{p}$	2.50	S	7.00	$\overline{p}$	3.00	S
c-27	7.50	$\underline{p}$	6.00	S	9.00	$\overline{p}$	2.50	S
c-28	5.90	$\underline{p}$	3.00	S	5.90	$\underline{p}$	4.90	S
c-29	8.00	$\underline{p}$	4.00	S	9.00	$\overline{p}$	3.70	S
c-30	6.00	$\underline{p}$	2.50	S	6.00	$\underline{p}$	2.50	S
c-31	5.90	$\underline{p}$	4.90	S	8.90	$\overline{p}$	4.00	S
c-32	6.00	$\overline{p}$	3.00	S	6.00	$\overline{p}$	3.00	S
c-33	7.00	$\overline{p}$	6.00	S	8.00	$\overline{p}$	5.00	S
c-34	9.90	$\underline{p}$	5.90	S	10.00	$\underline{p}$	5.00	S
c-35	9.00	$\underline{p}$	3.10	S	9.00	$\underline{p}$	3.10	S
c-36	7.80	$\underline{p}$	5.00	S	8.00	$\underline{p}$	5.00	S
c-37	8.00	$\underline{p}$	5.00	S	3.50	$\overline{p}$	6.50	S
c-38	8.00	$\overline{p}$	5.00	S	8.00	$\overline{p}$	5.00	S
c-39	9.90	$\underline{p}$	4.90	S	9.90	$\overline{p}$	4.90	S

2. Within-subjects treatments

Group 1

	first round						second round					
subject	bid A	bid B	bid C1	prize 1	bid C2	prize 2	bid A	bid B	bid C1	prize 1	bid C2	prize 2
1	5.00	5.00	9.00	$\overline{p}$	5.00	S	3.00	1.00	6.00	$\underline{p}$	5.00	$\underline{p}$
2	5.00	6.00	9.00	$\overline{p}$	4.00	S	10.00	6.00	6.00	$\overline{p}$	5.00	$\underline{p}$
3	5.10	6.10	6.10	$\overline{p}$	3.20	S	4.00	4.00	6.00	$\overline{p}$	3.00	S
4	8.40	7.60	8.90	$\underline{p}$	4.00	S	6.00	6.00	8.00	$\overline{p}$	6.00	$\overline{p}$
5	6.50	6.00	10.00	$\underline{p}$	4.00	S	5.00	6.00	9.00	$\overline{p}$	3.00	S
6	6.00	7.00	8.00	$\underline{p}$	4.90	S	6.00	7.00	8.00	$\underline{p}$	4.90	S
7	6.00	6.80	6.00	$\underline{p}$	2.60	S	5.80	6.80	6.50	$\overline{p}$	2.90	S
8	5.00	10.00	10.00	$\underline{p}$	5.00	S	10.00	4.80	6.70	$\overline{p}$	5.70	$\overline{p}$
9	7.50	7.00	9.80	$\overline{p}$	5.50	S	6.00	6.00	9.50	$\underline{p}$	6.50	$\overline{p}$
10	5.00	10.00	7.50	$\overline{p}$	7.50	S	5.00	7.00	6.20	$\overline{p}$	6.80	$\overline{p}$
11	5.00	9.80	9.80	$\underline{p}$	8.20	S	6.90	7.40	8.40	$\underline{p}$	8.40	$\overline{p}$
12	5.00	7.00	9.90	$\underline{p}$	4.90	S	7.00	6.50	9.90	$\underline{p}$	5.00	$\overline{p}$
13	6.00	6.00	9.00	$\underline{p}$	3.00	S	6.00	6.00	9.00	$\underline{p}$	3.00	$\overline{p}$
14	2.50	5.00	6.00	$\underline{p}$	5.00	S	5.50	6.00	6.50	S	-	-
15	5.00	6.00	10.00	$\overline{p}$	5.00	S	5.00	6.00	10.00	$\overline{p}$	5.00	$\overline{p}$
16	8.00	8.00	9.00	$\underline{p}$	8.00	$\overline{p}$	8.00	8.00	9.00	$\overline{p}$	7.00	$\underline{p}$
17	10.00	1.00	8.50	$\underline{p}$	5.00	S	7.50	8.00	8.50	$\underline{p}$	6.00	$\overline{p}$
18	5.10	5.90	8.50	$\overline{p}$	6.00	S	5.10	5.60	8.20	$\overline{p}$	5.60	$\overline{p}$
19	8.00	8.00	7.00	$\overline{p}$	5.00	S	6.00	6.00	8.00	$\overline{p}$	5.00	$\overline{p}$
20	9.00	6.00	6.00	$\overline{p}$	4.00	S	5.00	5.00	5.00	S	-	-

Group 2

	first round						second round					
subject	bid A	bid B	bid C1	prize 1	bid C2	prize 2	bid A	bid B	bid C1	prize 1	bid C2	prize 2
1	6.00	6.00	6.00	$\underline{p}$	3.00	S	6.00	6.00	6.00	S	-	-
2	6.00	6.00	6.00	$\underline{p}$	3.00	S	6.00	6.00	6.00	S	-	-
3	8.00	8.00	8.00	$\overline{p}$	8.00	S	8.00	8.00	8.00	$\underline{p}$	8.00	$\underline{p}$
4	6.50	6.80	8.00	$\overline{p}$	4.00	S	5.00	8.00	8.00	$\underline{p}$	4.00	S
5	6.00	6.00	10.00	$\underline{p}$	6.00	S	6.00	6.00	10.00	$\underline{p}$	6.00	S
6	10.00	10.00	10.00	$\overline{p}$	10.00	$\overline{p}$	10.00	10.00	10.00	$\underline{p}$	10.00	$\underline{p}$
7	6.80	6.80	7.20	$\overline{p}$	7.20	S	6.90	7.20	7.50	$\underline{p}$	4.80	S
8	5.10	5.10	5.00	$\overline{p}$	4.00	S	5.10	5.10	5.10	S	-	-
9	7.00	7.00	7.00	$\overline{p}$	3.00	S	7.00	7.00	7.00	S	-	-
10	6.00	6.00	6.00	$\underline{p}$	6.00	S	6.00	6.00	6.00	S	-	-
11	6.00	6.00	8.00	$\underline{p}$	6.00	S	6.00	6.00	8.00	$\underline{p}$	5.00	S
12	5.90	5.00	5.90	$\underline{p}$	5.00	S	5.80	5.00	5.90	S	-	-
13	7.50	7.50	7.00	$\overline{p}$	3.50	S	6.00	6.00	6.50	S	-	-
14	6.59	7.99	7.99	$\overline{p}$	7.99	S	4.99	7.99	7.99	$\overline{p}$	7.49	$\overline{p}$
15	7.00	7.00	8.00	$\underline{p}$	1.00	S	7.00	7.00	10.00	$\overline{p}$	1.00	S
16	6.50	6.50	6.50	$\underline{p}$	6.00	S	6.50	6.50	6.50	S	-	-
17	5.50	6.00	6.90	$\underline{p}$	3.30	S	6.90	6.00	4.00	S	-	-
18	7.81	4.71	9.80	$\underline{p}$	6.11	S	10.00	6.61	6.21	S	-	-
19	4.90	4.70	4.70	$\underline{p}$	5.00	S	5.00	5.00	5.00	S	-	-
20	6.80	6.80	6.80	$\underline{p}$	5.00	S	6.80	6.80	6.80	S	-	-

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